Proposal for FLUXNET Synthesis Publication:

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Other collaborators: FLUXNET colleagues interested in momentum flux to the land surface

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Title of paper and outline: **Momentum flux to the land surface: a FLUXNET perspective on quantifying the sum, dependencies, and variability**

Background

Momentum transfer to the Earth's land surface is a critical component to maintaining present-day atmospheric processes, yet its spatial distribution, temporal variability, and dependencies have thus far, not been adequately characterized using direct measurements. This momentum flux also appears to be changing, as recently noted by Vautard *et al.* (2010), who state that surface winds have decreased by 10% over the last 30 years. Vautard *et al.* (2010) attributed this decrease to changes in surface roughness, primarily land-use change and overall biomass size increases in the northern hemisphere, but did not relate wind velocities to vertical momentum fluxes. A related topic not considered by Vautard *et al.* (2010) concerns the direct response of the atmosphere to increased CO_2 concentrations. General circulation models suggest with increased CO_2, the poleward temperature gradient will decrease, resulting in decreased generation and dissipation rates of kinetic energy in the atmosphere (Lucarini *et al.*, 2010; Hernández-Deckers and VonStorch, 2010).

Regional and global atmospheric models rely on the momentum flux to conserve turbulent kinetic energy (TKE). Aerodynamic roughness lengths are an integral component to this parameterization, where the spatial configuration of topography and landcover types should have a direct impact on the atmospheric response, especially in the atmospheric boundary layer. Spatially or temporally varying fields such as landcover (*e.g.* deforestation and afforestation), vegetation dynamics (*e.g.* senescence), and natural climate variability (*e.g.* solar variability, El Niño/La Niña-Southern Oscillation) may also affect momentum transfer. Additionally, other future changes are just beginning that may also alter momentum transfer rates, such as CO_2 fertilization, irrigation-intensive agriculture, and large-scale wind power extraction. The true consequences of these potential changes is currently unknown. Thus, we propose the completion of the following research questions:

Research Questions

Objective 1 — Calculate the existing momentum flux to the land surface using the FLUXNET database on a one-half hour timestep, using $\tau = -(\rho \cdot u_*^2)$ where τ is the momentum flux, ρ is the air density, and u_* is the frictional velocity for that measurement station.

Objective 2 — Integrate this calculation to estimate the annual mean global land-surface momentum flux for the entire dataset.

Objective 3 — Explore potential daily, seasonal, and annual dynamics of momentum flux measurements.

Objective 4 — Explore the temporal relationship as a function of landcover and/or its associated roughness length with the measured vertical flux of horizontal momentum.

Objective 5 — Assess the role of the temperature and precipitation dynamics on the measured momentum flux.

After addressing these objectives, we will be a place to better quantify the potential impacts of both climate change and anthropogenic modification of local land-atmosphere interactions. By deriving the spatial, temporal, and global momentum fluxes from measurements, we will also be able to conduct a comparison to state-of-the-art global and regional models, thus adding an additional validation metric for the performance of these models. More fundamentally, exploring the dynamics of momentum flux to the land surface facilitates a more clear understanding of natural and anthropogenic influences on the momentum flux of the Earth System and provides a baseline for future analyses.

Proposed sites to be used

All available sites - LaThuile dataset

Proposed rules for co-authorship

Our policy for co-authorship is to recognize those who make a significant contribution to the manuscript (scientific design/data analysis/writing), cf. Royal Society Publishing Ethics: http://royalsocietypublishing.org/site/authors/policy.xhtml. Those individuals responsible for collecting, maintaining, and providing the dataset utilized in the analyses will be acknowledged. Additionally, the rules proposed by the latest official disclaimer for the FLUXNET synthesis will be respected.

References

Hernández-Deckers, D. and VonStorch, J. (2010). Energetics responses to increases in greenhouse gas concentration. *Journal of Climate*, **23**, 3874–3887.

Lucarini, V., Fraedrich, K., and Lunkeit, F. (2010). Thermodynamics of climate change: generalized sensitivities. *Atmospheric Chemistry and Physics*, **10**, 9729–9737.

Vautard, R., Cattiaux, J., Yiou, P., Thépaut, J., and Ciais, P. (2010). Northern hemisphere atmospheric stilling partly attributed to an increase in surface roughness. *Nature Geoscience*, **3**, 756–761.